Replacing the M40 Field Protective Mask

EWS Contemporary Issue Paper Thesis

Submitted by Captain MW Holcomb

to

Major Stophel, CG 3

20 February 2008

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
20 FEB 2008		**00-00-2008 to 00-00-2008**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Replacing the M40 Field Protective Mask	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
United States Marine Corps,Command and Staff College, Marine Corps Combat Development,Marine Corps University, 2076 South Street,Quantico,VA,22134-5068	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**19**	

1949-2007

Article 3
In order more effectively to achieve the objectives of this Treaty, the Parties, separately and jointly, by means of continuous and effective self-help and mutual aid, will maintain and develop their individual and collective capacity to resist armed attack.
North Atlantic Treaty Organization (NATO) Charter, 1949

. . . increased attention must be paid to . . . standardization [sic]*, as well as to the challenges posed by the accelerating pace of technological change and the different speeds at which Allies introduce advanced capabilities.*
NATO Defence [sic] Capabilities Initiative, 1999

The Department of Homeland Security, working with the White House and other federal departments, would set the overall direction for our Nation's homeland security research and development. The Department would establish a management structure to oversee its research and development activities and to guide its interagency coordination[1] *activities.*
The National Strategy for Homeland Security (NSHS), 2002

In order to assist with the full assimilation of resources and assets, we will continue to develop comprehensive and integrated logistics systems and procedures that enhance our Nation's overall response capabilities
NSHS, 2007

[1] Author's Note - The management structure envisioned here to promote interagency coordination was realized with the creation of the InterAgency Board for Equipment Standardization and Interoperability (IAB). It is sanctioned by the Attorney General of the United States and was founded by the Department of Defense's Consequence Management Program Integration Office and the Department of Justice's Federal Bureau of Investigation Weapons of Mass Destruction Countermeasures on October 13, 1998. (http://www.iab.gov/)

The United States military is on the verge of fielding a new protective mask known as the Joint Service General Purpose Mask (JSGPM). This mask is legally compliant with various international treaties, Presidential directives, and federal regulations, but it does not meet their intent to improve standardization and interoperability. The US Armed Forces should not accept the JSGPM, as it currently exists, because it cannot provide the interoperability, compatibility, and flexibility of other masks that have a 40mm STANAG 4155[2]/QSTAG 695[3]/NFPA[4]/NIOSH[5] compliant filter attachment.

Background

JSGPM 1

Due to shortcomings of the M40 field protective mask and the use of five different ground forces masks[6] by various services, a new Department of Defense wide mask was sought. The JSGPM project was initiated in 1998.[7] In 2002 the contract was awarded to Avon Rubber and Plastics Inc. of Cadillac, Michigan, a division of

[2] STANAG – NATO Standardization Agreement
[3] QSTAG - Quadripartite Standardization Agreement
[4] NFPA - National Fire Protective Association
[5] NIOSH - National Institute of Occupational Safety and Health
[6] 106th Congress 1999
[7] PM NBC Defense "Walks the Talk" in Acquisition Reform 1998

the British company Avon Rubber. The contract included the entire lifecycle of the masks,[8] and it included a number of goals:

-Protection against toxic industrial chemicals and materials (TIC/TIMs)[9]

-Reduced weight and bulk compared with M40/M42/MCU-2/P masks[10]

-Inhalation breathing resistance less than or equal to 30 mm H2O at 85 LPM[11]

The JSGPM program succeeded in a number of areas. The new mask provides a better field of vision through a single eye lens, allowing a user to be more aware of his or her surroundings. It also has a vastly improved communication system centered on an internally mounted microphone, enabling the user to be clearly understood.[12]

Moreover, the JSGPM uses a new technically improved filter system. To achieve the initial goal of reducing breathing

JSGPM 2 JSGPM/M50 Filter - note the curved shape and filtration materials

[8] NBC Defense Systems 2003
[9] JPEO-CBD JSGPM Presentation 2006
[10] JPEO-CBD JSGPM Presentation 2006
[11] JPEO-CBD JSGPM Presentation 2006
[12] Author's personal experience using the JSGPM and numerous other types of respiratory protection with full face masks

resistance by 50% from the M40,[13] dual filters with reduced bed depth were used, as opposed to a single air intake[14] with thicker C2A1 canister.[15] The materials used in the new filter design allowed the engineering team to shape the filters better than they were able to with conventional charcoal filters.[16]

This was done to increase the comfort of the mask and to achieve a better sight picture while using a rifle. However the new filter presents problems with interoperability, compatibility, and flexibility.

Problems with partner nation interoperability

> *They [NATO Forces] must be interoperable and have appropriate doctrines and technologies.*
> The Alliance's [NATO] Strategic Concept, 1999

> *Key features include… common standards and procedures for equipment, training and logistics; joint and combined doctrines and exercises when appropriate; and infrastructure, armaments and logistics cooperation.*
> The Alliance's [NATO] Strategic Concept, 1999

Internationally, both the Quadripartite[17] Standardization Agreement (QSTAG 695)[18] and NATO Standardization Agreements

[13] Puckace, K "The New Face of Protection." July 2007
[14] The M40 can be used in a dual canister mode, but that is not the standard configuration.
[15] JPEO-CBD JSGPM Presentation 2006
[16] JPEO-CBD JSGPM Presentation 2006
[17] Author's Note – The treaty is between the America, Britain, Canada, and Australia. It is also known as the ABCA group.
[18] Department of Defence Index of Specifications and Standards 2001

(STANAG 4155)[19] agreed that the standard attachment for a filter to a protective mask would be 40mm with a 1/7 turn. The Joint Program Executive Office for Chemical and Biological Defense (JPEO-CBD) notified the other member countries that the US was going to a new bayonet locking lug attachment method, and that the US position was the current agreements only applied to masks that had a threaded filter design.[20]

This was a mistake because "The fundamental guiding principle by which the Alliance works is that of common commitment and mutual co-operation among sovereign states in support of the indivisibility of security for all of its members."[21] NATO works because of trust between the members. If the US is acts in a

NATO 1 – From STANAG 4155

AIM

1. (a) The aim of this agreement is to provide for full mechanical interchangeability between NBC Protective Masks and Filter Canisters for NATO forces irrespective of national origin of masks and canisters.

(b) This agreement is intended for use by the NATO armed forces.

AGREEMENT

2. Participating nations agree to equip the NBC protective masks and filter canisters with a rolled thread RD 40 x 3,63 mm as in Annex A.

IMPLEMENTATION

3. This STANAG will be considered implemented when nations concerned:

- have equipped their forces with NBC protective masks and filter canisters with rolled threads conforming to this STANAG; and by incorporating the provisions of Annex A into their national procurement specification; or
- guarantee the mechanical interchangeability of their forces' masks and filters with those of other nations through appropriate means.

NATO UNCLASSIFIED

[19] Avon Protection 2006
[20] Fritch, William Email shared with the author by the Program Manager for the Respirator Engineering and Acquisition Team 2005
[21] NATO Heads of State and Government 1999

unilateral matter that does not support the Alliance, it may be detrimental to NATO's strength. While enough legal "wiggle room" exists to justify using the new system, it will affect the way the Alliance operates as the treaty. Every time members do not support each other fully, the NATO charter is weakened. If it is weakened enough, the Alliance may become irrelevant, as states may not respond to the mutual defense request of a member who is perceived to act in self-interest only.

Alliance forces also need to rely on each other for logistical support. "Standardisation [sic] will foster cooperation and cost-effectiveness in providing logistic support to allied forces."[22] Moreover, it hinders Alliance logistical efforts, in war or disaster response, if NATO members use multiple types of filters. One key example would be the use of the Multinational CBRN Battalion. Every rotation between six and eight countries commit forces to this unit,[23] with every country bringing its own equipment. CBRN operations are already one of the most logistically challenging because of the amount of protective equipment that is expended, and basic equipment that is not usable by the entire unit only enlarges the problem.[24]

---

[22] NATO Heads of State and Government - The Alliance's Strategic Concept, 1999
[23] North Atlantic Treaty Organization Topics - The Chemical, Biological, Radiological, and Nuclear Defence Battalion 2007
[24] Author's note – I was able to watch the certification exercise of rotation eight in the Czech Republic October 2006. The United States was not, by far,

Problems with interoperability and the Department of Homeland Security (DHS) and the first responder community

> *15) To the extent permitted by law, equipment purchased through Federal preparedness assistance for first responders shall conform to equipment standards in place at time of purchase. Other Federal departments and agencies that support the purchase of first responder equipment will coordinate their programs with the Department of Homeland Security and conform to the same standards.*[25]
>
> President George Bush in Homeland Security Presidential Directive (HSPD) 8, 17 December 03

The United States has a similar problem with standardization internally. Despite the NSHS for both 2002[26] and 2007,[27] as well as HSPD 5[28] and 8,[29] calling for unity of effort, the Department of Defense (DoD) has chosen to go its own way with the JSGPM. The IAB,[30] using NIOSH and NFPA standards, was set up to accomplish part of the task: "The Federal Government is also responsible for developing national strategies as well as promulgating best practices, national standards for homeland

---

the largest force provider. With a separate filter, relying on another nation for logistical would be impossible and would lead to either a larger footprint, or withdrawing from the Multination CBRN Battalion.

[25] President George Bush Homeland Security Presidental Directive 8 2003

[26] National Strategy for Homeland Security 2002

[27] National Strategy for Homeland Security 2007

[28] President George Bush Homeland Security Presidental Directive 5 2003

[29] President George Bush Homeland Security Presidental Directive 8 2003

[30] IAB Mission - The InterAgency Board (IAB) for Equipment Standardization and Interoperability is designed to establish and coordinate local, state, and federal standardization, interoperability, compatibility, and responder health and safety to prepare for, train and respond to, mitigate, and recover from any incident by identifying requirements for an all-hazards incident response with a special emphasis on Chemical, Biological, Radiological, Nuclear or Explosive (CBRNE) issues. (http://www.iab.gov/)

security and national Plans, as appropriate."[31] This included DHS accepting the standard set by NIOSH, the NFPA, and 29 CFR 1910[32] for respiratory protection filters.

Granted, DoD was exempted by both NSHS 2002 and NSHS 2007 from the national standards. In both President Bush stated "Nothing in this directive impairs or otherwise affects the authority of the Secretary of Defense over the Department of Defense."[33] However, the JSGPM does violate the President's intent to promote interoperability and compatibility among organizations that work together conducting disaster response. As the President also stated, "the Secretary of Defense and the Secretary [DHS] shall establish appropriate relationships and mechanisms for cooperation and coordination between their two departments."[34]

One example is the problem the JSGPM creates is the lack of interoperability with the Coast Guard, which belongs to DHS during peacetime, and DoD during war. Deployed Coast Guard units may not be able to rely on the Navy for resupply of NBC equipment, creating a potential vulnerability for a chemically equipped opponent to exploit.

[31] National Strategy for Homeland Security 2007
[32] CFR – Code of Federal Regulations – 29 CFR 1910 covers workplace safety, to include hazardous materials operations
[33] National Strategy for Homeland Security 2002
[34] National Strategy for Homeland Security 2002

Another key weakness in not staying with the national standard is a limited ability to protect U.S. forces from TIC/ TIMs. In the manufacturing sector today, a number of chemicals formerly considered chemical warfare agents (CWAs), including chlorine, phosgene, and cyanidates, are now widely used in production. A risk assessed list of chemicals called the ITF 40[35] lists the chemicals by a combination of toxicity and quantity.[36] Various companies, such as Scott[37] and 3M,[38] design filters specifically to protect against particular chemicals. The JSGPM rightfully has a compromise filter that protects against most CWAs and some TIC/TIMs, but the filter attachment system limits DoD's ability to use specific filters to protect against specific chemicals when responding to terrorist strikes against US chemical infrastructure, or industrial accidents.

One horrific example of this potential happened on December 3, 1984 at the Union Carbide plant in Bophol, India, when methylisocyanate was released into the atmosphere.[39] This one incident resulted in at least 3,828 dead and 100,000 injured.[40] The C2A1[41] canister is not listed as protecting against this chemical.[42] (The JSGPM filter specifications are not public, but

[35] ITF – International Task Force
[36] Resta, J International Task Force 40 Operational and Medical Concerns 2001
[37] Scott Filters
[38] 3M Responder Products for Domestic Prepardness
[39] Union Carbide Bophol Information Center, 2007
[40] Union Carbide Bophol Information Center, 2007
[41] Standard DoD issued filter
[42] 3M C2A1 User Instructions, 2003

it provides limited TIC/TIM protection.[43]) Union Carbide[44], and others, operate vinyl and plastics manufacturing facilities across the United States.

If DoD was asked to assist civilian authorities with immediate response in the aftermath of a major incident the JSGPM could severely hinder the response. As an example, after a terrorist attack on a chemical facility, a chemical that causes severe burns to soft tissue (eyes, nose, throat, lungs) was released in mass quantities. Local and state first responders enter the affected area and are quickly overwhelmed by the scope of the problem. DoD assistance is requested and initial units arrive within hours: National Guard Civil Support Teams and the Marine Corps' Chemical Biological Incident Response Force.[45] These mission specific units assist the first responders until the arrival of larger units.

The next to arrive are a USMC infantry regiment on the JTF-CS CCMRF[46] rotation and a National Guard CBRNE Enhanced Response

[43] JPEO-CBD JSGPM Presentation 2006
[44] Currently owned by Dow Chemical Corporation
[45] CBIRF – A highly skilled, rapid response unit whose sole mission is to respond to CBRNE incidents. CBIRF conducts casualty extraction and decontamination, search and rescue, medical treatment and stabilization, agent detection and identification, and specialized EOD operations. Author served at CBIRF as a company commander and as the operations officer.
[46] Joint Task Force Civil Support CBRNE Consequence Management Response Force. "The CCMRF consists of a rotational pool of active and reserve units from each of the services. In addition to their normal defense mission, when assigned to the CCMRF rotation, these units are kept on short notice to conduct a secondary mission of domestic consequence management should the need arise." LCDR P. A. Gist, former JTF-CS J4

Force Package[47]. Their task is to search a large urban area that the gas blew through and find all of the injured, many of whom are blind and in respiratory distress, that sheltered in place or did not escape. However, units soon realize that the JSGPM filter will not adequately protect them from this chemical.

The local first responder community has conducted a risk assessment of this chemical facility and stockpiled the appropriate 40mm filter for use in an incident. But the Marines and National Guardsmen are unable to use 40mm filters, so many more people die. Then the news media broadcasts Marines and Soldiers standing around watching, seemingly helpless, as victims in the upper stories of building wave sheets and yell for assistance.

Problems with flexibility regarding suppliers

> *However, having won the contract for the new US military respirator, we identified respiratory protection as an area of significant growth potential with the requirement for substantial investment* [for other companies to compete]*. It is a market where we are confident we can obtain higher margins. And with the business underpinned by a strong military contract we expect the earnings to be sustainable.*[48]
>
> Avon Chief Executive Terry Stead at the Avon Annual General Meeting, January 2007

Avon is the patent owner and manufacturer of the proprietary bayonet locking lug filter attachment system, and

[47] CERFP's are National Guard Units that receive some additional CBRNE training requirements on top of their regular skill sets.
[48] Stead, T Avon Rubber Annual General Meeting January 2007

they have not allowed another company to manufacture the filter.[49] While JPEO-CBD is attempting to get NIOSH and allied nations to agree on a new standard in order to take advantage of the technological improvements,[50] the U.S. is also directly subjugating other countries to the price scheme set up by Avon. Without any competition for Avon, they have little financial incentive to develop new filters, or even license out their patent. While the U.S. does have a "limited data rights arrangement"[51] with Avon, this arrangement is not the same as several companies developing and competing to offer new types of filters.

Solutions

> *All of this [current security environment] requires Allies to continue the process of transformation, including conceptual and organisational [sic] agility and the development of robust capabilities that are deployable, sustainable, interoperable, and usable.*[52]
>
> Comprehensive Political Guidance issued by the NATO Heads of State and Government, 29 November 2006

Two solutions to the problems described above are to create an adaptor for JSGPM or purchase another mask. Creating an adaptor would have the least impact on the funding and fielding of the mask. Replacing the JSGPM would significantly increase

[49] Fritch, W Program Manager for the Respirator Engineering and Acquisition Team Email interview with the author 2007
[50] Fritch, W Email interview with the author 2007
[51] Fritch, W Email interview with the author 2007
[52] NATO Heads of State an Government Comprehensive Political Guidance Nov 2006

the program costs and delay fielding but could eliminate the problem completely. The challenge then is to keep the best of the JSGPM technology.

If the JPEO-CBD decided to purchase an adaptor, it would allow DoD to use the best of current and next generation filter technology, drive filter costs down, and provide U.S. partners, domestic and internationally, with options. This adaptor would have the JSGPM proprietary bayonet lug system on one side and a 40mm 1/7 thread on the other. This small part, which could be cheaply manufactured in large quantities, would be issued as an accessory to the mask, much like the tinted lenses. Fielding this adaptor could even be done after the mask was initially issued.

Purchasing a different mask would be vastly more challenging and expensive. By sticking with Avon, DoD might reduce some of those costs and still take advantage of other new technologies in the mask. Two of their masks initially look promising, the M53 and the C50. Both are compliant with the QSTAG/STANAG standards, and the C50 has even been certified by NIOSH. It was also developed from the JSGPM as a "non-military variant for use in homeland security and industrial markets."[53] Another choice is the M53, the new mask being fielded to Special

[53] Stead, T Avon Rubber Annual General Meeting January 2007

Operations Command.[54] This mask is more expensive to purchase and operate due to its ability to be used in both positive and negative pressure modes. However, the mask is a current program that could be rapidly expanded, as opposed to starting a new program. The M53 also has a significant advantage over the M40 and JSGPM for ground combat; it was designed to provide a significantly better sight picture when firing a rifle. To accomplish this each mask is either set up for right handed or left handed individuals, not both. The filter attachment is placed on the opposite side which the military member shoots. On the shooting side, a hard flat section aligns with the user's rifle, creating a good cheek to stock weld.

Avon Supplied Performance Data

Inhalation Resistance at	C50	FM53	FM50 (JSGPM)
30 L/Min	3mm WG	7mm WG	10mm WG
95 L/Min	13mm WG	16mm WG	30mm WG
160 L/Min	23mm WG	32mm WG	64mm WG
Weight	490 grams	570 grams	840 grams

M53 1
Note flat cheek surface opposite filter for weapon stock weld. (Avon brochure)

[54] As well as various select units, like the Marine Corps Chemical Biological Incident Response Force

Counter-arguments

JSGPM 3
JSGPM/M50 Filter - note the clip locks on the side and the bayonet ring in the middle that opens the receiver on the mask. This closes when the filter is removed, limiting contamination during filter exchanges.

Program delays and cost overruns are among the many valid arguments against switching masks. However, the same arguments cannot be made against the adaptor. This item would not delay the program because it could be fielded separately. Some additional costs in testing, and a minimal amount in production, as well as in creating a licensing arrangement with Avon would be incurred.

Conclusion

The next generation mask could be made more flexible in use, compatible with current standards, and interoperable with international and domestic partners. The development and acquisition of a filter adaptor would take a moderate investment but would allow the US Armed Forces to take advantage of the best in current and future filter technologies.

1997 Words

Biblography

106th Congress. "Hearing Before the Committee on Armed Services, House of Representatives, Questions and Answers for Protection Equipment and Countermeasure Devices." *Committee Documents US House of Representatives.* February 11, 1999. http://commdocs.house.gov/committees/security/hasQA04220.000/hasQA04220_0f.htm (accessed December 17, 2007).

3M. C2A1 User Instructions. 2003. http://multimedia.3m.com/mws/mediawebserver?66666UuZjcFSLXTt5X&EN8z6EVuQEcuZgVs6EVs6E666666-- (accessed December 15, 2007).

3M Responder Products for Domestic Prepardness. http://solutions.3m.com/wps/portal/3M/en_US/Health/Safety/Products/Catalog/?PC_7_RJH9U5230GE3E02LES9MG812H2_nid=HFFLXCG6V5beQQFFG1G8R7gl (accessed December 17, 2007).

Avon. "C50 Brochure." Avon-Protection.com. January 15, 2007. http://www.avon-protection.com/data/Final%20C50%20Brochure%2015012007.pdf (accessed December 15, 2007).

—. "FM50 Brochure." *Avon-Protection.com.* August 29, 2007. http://www.avon-protection.com/assets/FinalFM50datasheet.pdf (accessed December 2007, 2007).

—. "FM53 Brochure." *Avon-Protection.com.* August 22, 2007. http://www.avon-protection.com/data/Final%20C50%20Brochure%2015012007.pdf (accessed December 2007, 15).

-. "Summary Data Sheet for Avon AMF12 NBC Filter Canister." *Avon-Protection.com.* March 2006. http://www.avon-protection.com/data/AvonProtectionAMF12NBCFilterCanister.pdf (accessed December 17, 2007).

"Department of Defence Index of Specifications and Standards." *Department of Defence Single Stock Point for Military Specifications, Standards, and Related Publications.* October 15, 2001. http://dodssp.daps.dla.mil/dodiss/oct15_01.pdf (accessed December 17, 2007).

Fritch, William. *Email interview with the author.* Aberdeen Proving Grounds, MD, December 6, 2007.

Fritch, William Program Manager Respirator Engineering and Acquisition Team. *Email shared with the author.* Aberdeen Proving Grounds, MD, September 26, 2005.

JPEO-CBD. "Joint Service General Purpose Gas Mask (JSGPM) and Joint Service Chemical Environment Survivability Mask (JSCESM)." *DTIC.mil.* March 2006. www.dtic.mil/ndia/2006cbip/fritch.pdf (accessed December 3, 2007).

National Strategy for Homeland Security 2002. Washington DC: US Government, July 16, 2002.

National Strategy for Homeland Security 2007. Washington DC: US Government, October 5, 2007.

NATO Heads of State and Government . *The Alliance's Strategic Concept.* April 24, 1999. http://www.nato.int/docu/pr/1999/p99-065e.htm (accessed December 16, 2007).

—. *Comprehensive Political Guidance issued 29 November 2006.* November 29, 2006. http://www.nato.int/docu/basictxt/b061129e.htm (accessed December 16, 2007).

—. *Defence Capabilities Initative.* April 25, 1999. http://www.nato.int/docu/pr/1999/p99s069e.htm (accessed December 16, 2007).

"NBC Defense Systems." Association of the United States Army. October 1, 2003. http://www.ausa.org/webpub/DeptGreenBook.nsf/byid/CTON-6CGLZY (accessed December 17, 2007).

North Atlantic Treaty Organization Charter. Brussels Belgium, August 24, 1949.

North Atlantic Treaty Organization Topics - The Chemical, Biological, Radiological, and Nuclear Defence Battalion. January 2007. http://www.nato.int/issues/cbrn/participation.html (accessed December 15, 2007).

President George Bush. *Homeland Security Presidental Directive 5.* Februrary 28, 2003. http://www.whitehouse.gov/news/releases/2003/02/20030228-9.html (accessed December 14, 2007).

—. *Homeland Security Presidential Directive 8.* December 17, 2003. http://www.whitehouse.gov/news/releases/2003/12/20031217-6.html (accessed December 15, 2007).

Puckace, Kevin E. "The New Face of Protection." *Chem-Bio Defense Quarterly*, July 2007: 26-27.

Resta, John. "International Task Force 40 Operational and Medical Concerns." *Aberdeen Proving Grounds.* August 16, 2001. http://chppm-www.apgea.army.mil/desp/pages/jeswg/4QFY01/itf-40-2US.ppt (accessed December 17, 2007).

SBCCOM CB Quarterly. "PM NBC Defense "Walks the Talk" in Acquisition Reform." December 1998: 18-19.

Scott Filters. http://www.scottint.com/categories/Air-Purifying/Filters/2574 (accessed December 17, 2007).

STANAG 4155. Emailed to author by W. Duensing Section Chief Administration NATO Standardisation Agency

Stead, Avon Chief Executive Terry. "Avon Rubber Annual General Meeting." *Avon-Rubber.com.* January 25, 2007. http://www.avon-rubber.com/corporate/press/2007/AGM_2007_CEO_Presentation_with_notes.pdf (accessed December 17, 2007).

Union Carbide. *Bophol Information Center.* November 2007. http://www.bhopal.com/chrono.htm (accessed December 17, 2007).